

STATUS AND OPERATION OF WET FGDS FOR THERMAL POWER PLANTS IN KEPCO

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ABSTRACT

To meet the new stringent sulfur dioxide (SO_2) emission standards effectuated from Jan. 1999 for thermal power plants in Korea, KEPCO (Korea Electric Power Corporation) has implemented environmental protection program to control emissions of SO_2 in the flue gas. The major action to reduce SO_2 emitted from thermal power plants is the installation of wet limestone scrubbing systems. 27 units among 31 units of FGD (flue gas desulfurization) systems have already been operated and 4 units will be commissioned by 2002.

This paper presents the status of FGD (Flue Gas Desulfurization) system applications on thermal power plants in KEPCO. In addition, operating experiences of 200MW FGD demonstration plant developed by KEPRI (Korea Electric Power Research Institute) will be also discussed.

1 INTRODUCTION

Environmental considerations will be a restraining factor with using fossil fuel in thermal power plants. Especially, air quality and global warming problem are becoming hot issues in the world. In Korea, recently new stringent emission limits for thermal power plants set up. Accordingly, KEPCO concentrated every effort on reinforcing emission control policies to meet the new emission standards.

To meet the new stringent SO_2 emission limits for thermal power plants in Korea, KEPCO has implemented environmental protection program to control emissions of SO_2 in the flue gas. The major action to reduce SO_2 emitted from thermal power plants is the installation of wet limestone-based FGD systems. 27 units among 31 units of FGD systems have already been operated as of September 2000 and 4 units are under construction, which will be commissioned by 2002. Then total capacity of FGD systems will be reached to 12,825MW. All of the FGD systems installed in KEPCO consist of LSFO (limestone forced oxidation) process.

Among FGD systems installed in KEPCO, 27 units were constructed by foreign technologies and the only 4 systems were applied to KEPAR (Korea Electric Power Corporation Absorption Reactor) developed by KEPRI.

This paper presents the current status of FGD system applications on thermal power plants in KEPCO. In addition, operating experiences of 200MW FGD demonstration plant developed by KEPRI will be also discussed.

2 AIR QUALITY PRESERVATION ACT OF KOREA

The Air Quality Preservation Act was enacted to preserve human health and the environment due to air pollution. To this end, the laws set specific emission limits for pollutant emissions from facilities and impose charges for the pollutants discharged. The permissible emission limits of air pollutants emitted from facilities are determined by the Ordinance of the Ministry of Environment. SO_2 emission limits in Korea have become stringent. Table 1 shows permissible emission standards for thermal power plants. As can be seen in Table 1, coal-fired power plants have to comply with the SO_2 emission level of 120-270 ppm and in the case of oil-fired power plants is 120-180 ppm. SO_2 emission limits will become more stringent in the near future as expected.

3 SULFUR OXIDES EMISSION

SO₂ is one of the major pollutants to be reduced for improving air quality in Korea. Table 2 shows the trend of SO₂ emissions from fossil fuel combustion, which has gradually decreased by strict environmental policies since 1994. The shares of SO₂ emission of electric utilities have also been decreased since 1994. It accounted for about 16.5% of nationwide emission in 1998, in addition, the amount of SO₂ emission decreased drastically in 1999 due to the operation of FGD systems.

4 STATUS OF FGD SYSTEM AT THERMAL POWER PLANTS IN KEPCO

In 1999, coal-fired power units comprise 27.8% of the total capacity of 44,427MW in KEPCO. It is anticipated that the total power generating capacity will gradually increase up to 51,917MW and share of coal burning power units will be up to 29.3% in 2002. Although coal is relatively inexpensive and effective for utility power generation, coal-fired power plants generate a considerable amount of pollutants such as SO₂, NO_x and dust.

KEPCO prepared construction program of FGD system to meet the emission limits and began to install FGD system in 1994.

Now 27 units of FGD systems are being operated, 4 units are under construction, a total capacity of FGD systems amounts to 12,825MW. All FGD systems are wet limestone process to produce salable gypsum. 27 FGD units have been constructed by 15 domestic companies which were made license agreements with 6 foreign companies such as B&W, Steinmuller, MHI and so on. The other 4 units had been installed by the technologies of KEPRI.

Table 4 shows the construction program of FGD systems for thermal power plants at KEPCO.

5 OPERATING EXPERIENCES OF 200MW FGD

Principle and characteristics of KEPAR process

KEPAR is a new type of FGD absorber developed by KEPRI. This reactor combines the features of a double-loop bubble column and a sieve tray in a unique way to achieve gas/liquid contact and SO₂ removal. It uses inexpensive limestone as the reagent and utilizes a forced oxidation to produce salable-grade gypsum. Two power plants were retrofitted with KEPAR, which is operating successfully.

Conventional tray tower has multi-staged sieve trays and intakes the absorption liquid and flue gas from both top and bottom of the trays, and lets the gas and liquid phases contact each other by generating froth on each tray. Thus its pressure loss is high, and either flooding or weeping phenomena can happen due to the unbalance between gas and liquid velocity.

Since the range of gas velocity for generating stable froth is quite narrow, the conventional one has poor responsiveness for load change of boiler. In designing of KEPAR, merits of tray tower and loop bubble column were incorporated to maximize the efficiency of gas-liquid contact.

As demonstrated in Fig. 1, KEPAR uses single stage sieve tray and lets the absorption liquid in the reactor circulate naturally, therefore it does not require slurry re-circulation pump.

The process keeps the absorption liquid to a certain level on the top of the sieve plate, and intakes the flue gas through gas inlet duct. Then the flue gas forms a gas layer beneath the sieve plate and is ejected into the absorption liquid through gas holes, which forms froth on the top of the sieve plate. The absorption liquid that absorbs SO₂ from the froth zone flows over the overflow weir and circulates to the bottom of the reactor through down comer at a speed determined by the density difference of the absorption liquid between the inside and the outside of the overflow weir.

If the pressure of the gas layer is in equilibrium, the liquid level remains constant, and the same amount of fresh absorption liquid as that of overflowed one rises through liquid riser to the froth zone on the sieve plate, thus it absorbs the SO₂ continuously.

Liquid to gas ratio (L/G) for the absorption tower is defined as the ratio of the amount of absorption liquid slurry to the unit volume of flue gas in terms of either gal/1,000ft³ or •/Nm³.

As L/G ratio increases the SO₂ removal efficiency improves, however, it needs more power consumption of slurry re-circulation pump. L/G ratio ranges normally from 8 to 14 •/Nm³ for the spray tower. In case of KEPAR, L/G ratio is meaningless because KEPAR is operated without slurry re-circulation pump. SO₂ removal efficiency depends upon mainly absorber ΔP in the KEPAR. But the internal geometry of absorber including pitch of gas inlet duct, gas hole pitch, hole density, height and length of the overflow weir, and the ratio of hole area to active area should be optimized to form a stable formation of froth layer and then to achieve high absorption efficiency. The operating pH of

KEPAR is low, 4 - 5, compared to that of spray tower, 5 - 6, thus the oxidation reaction rate is fast and the limestone can be more efficiently utilized. However, there is a little limitation in choosing material for internal parts of the absorption tower because of low pH.

Applications to Youngdong power plants

FGD system overview and design

The FGD system of unit 2 at Youngdong power plant consists of single absorber, oxidation air system, limestone feeding system, gypsum treatment system, and wastewater treatment system. Flue gas from boilers enters electrostatic precipitator (ESP) where particulate matter is removed. Then the flue gas is directed to booster fans through the induced fans. Flue gas is pressurized to overcome the FGD system pressure drop by two 50% capacity booster fans. Flue gas leaving the booster fans enters the hot side of a gas-gas heater (GGH). The GGH is a rotating, horizontal-shaft Ljungstrom-type heat exchanger that transfers heat from the inlet gas to the cooler outlet gas from the absorber. Partially cooled flue gas from the GGH enters a duct cooler, where it contacts recirculating slurry. Then flue gas enters and forms gas-liquid mixture on the sieve tray where SO_2 is absorbed. The absorbed SO_2 is completely oxidized to form calcium sulfate (gypsum) by addition of oxidation air and limestone slurry. Treated flue gas from the absorber passes through two stages of mist eliminator before entering the cool side of the GGH where it is reheated. After passing through the GGH, treated flue gas is directed to the stack for dispersion in atmosphere.

Limestone slurry of 20wt.% is pumped from limestone slurry sump to absorber. Limestone slurry is prepared by powdered limestone of 90% thru 325mesh.

Gypsum dewatering system consists of primary and secondary dewatering systems, conveying equipment and storage building. The primary dewatering system consists of banks of hydro cyclones, which dewater the slurry from the absorber from 20wt.% to 45wt.% solids. The thickened slurry is then sent to vacuum belt filter where it is dewatered to 90wt.% solids. The filter cake is washed before discharge from the vacuum belt filter to remove chloride content to acceptable wallboard quality standards.

The flow diagram of FGD system at Youngdong power plant is shown in Fig. 2. The 200MW FGD system with KEPAR, which was built in Yongdong power plant in Korea, began commercial operation in January 1999 after 1-year test operation and successful performance test.

Unit 2 boiler of Youngdong thermal power plant burns a fuel composed of 70% domestic anthracite coal and bunker-C oil. Table 5 is a summary of the major design conditions of the KEPAR FGD process.

Operational Results

The SO_2 removal efficiency of the KEPAR was measured under five absorber ΔP and 4 pH ranges. The sulfur content of coal and bunker-C oil for test was a 0.4% and 4% respectively. Figure 3 shows the effect of absorber ΔP on SO_2 removal efficiency at constant pH and illustrates the increase in SO_2 removal efficiency as absorber ΔP increase.

Fig. 4 illustrates the relationships between boiler load and SO_2 removal efficiency at constant pH. SO_2 removal efficiency decreases as boiler load increases. The absorber ΔP was maintained at 300mmAq and the inlet concentration of SO_2 was held from 800 to 900ppm.

A summary of performance test results is shown in Table 6. Under the typical operating conditions, the SO_2 removal efficiency was 93.3%. The system responded well automatically, even with load changes. The absorber removed more than 90 % of the particulate. 96.1 % purity gypsum from the vacuum belt filter was produced and is sold to cement manufacturing. Table 7 shows analyses of the by-product gypsum.

5 SUMMARY

To meet the new stringent emission limits KEPSCO prepared construction program of FGD system and began to install FGD system in 1994. Now 27 units of FGD systems are being operated and 4 units are under construction, and total capacity of FGD systems amounts to 12,825MW.

200MW demonstration FGD plant with KEPAR was applied to a unit 2 of Yong Dong thermal power plant burning domestic anthracite coal and bunker-C oil. Now it is being operated successfully. Ongoing R&D is focused on improved design and reduced operating and maintenance costs.

